5 EVALUATION OF VAPOR EXTRACTION AND MONITORING DATA

An evaluation of vapor extraction and soil-vapor monitoring data was conducted to understand the impact and effectiveness of past OU 7-08 remediation activities. The evaluation is anticipated to lead to more efficient strategies for removing organic contamination from the vadose zone and to help meet project objectives outlined in the OU 7-08 ROD (DOE-ID 1994).

The evaluation consisted of summarizing and analyzing existing operational and monitoring data using the following specific tasks:

- Organize and present operational uptime/downtime data for the VVET units
- Combine uptime/downtime data with inlet vapor concentration data and subsurface vapor concentration data and evaluate vapor extraction trends as they relate to rebound and mass removal.

5.1 Evaluation Background

Figure 5-1 shows the location of 743-series waste drum burials, which are the primary source of VOCs in the SDA. Volatile organic compounds have been released from the waste into the vadose zone, creating a large vapor plume that extends from land surface to the Snake River Plain Aquifer. Figure 5-2 is a conceptual drawing of the vadose zone VOC plume based on carbon tetrachloride vapor samples. The drawing represents the plume before any remedial actions.

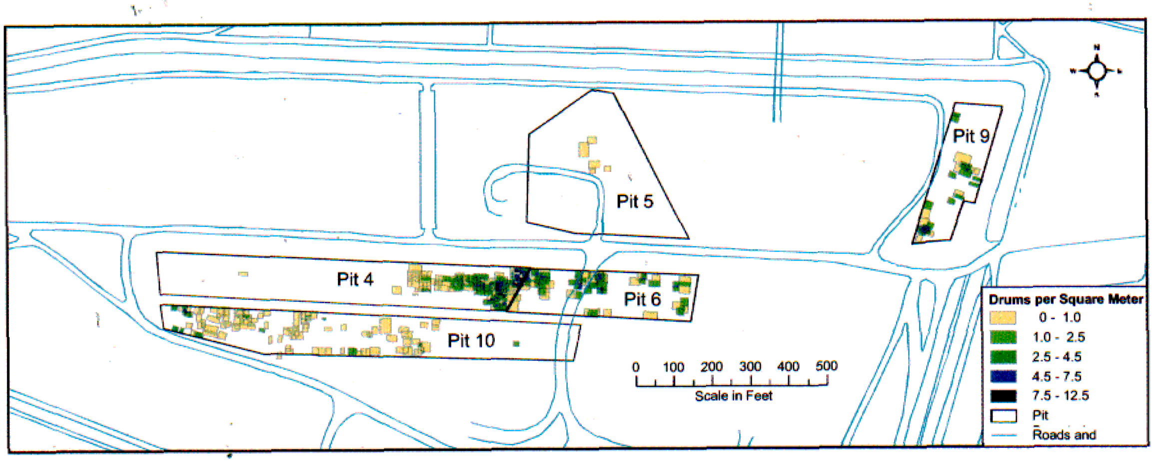


Figure 5-1. Map of the Subsurface Disposal Area showing relative drum burial densities for 743-series waste drums.

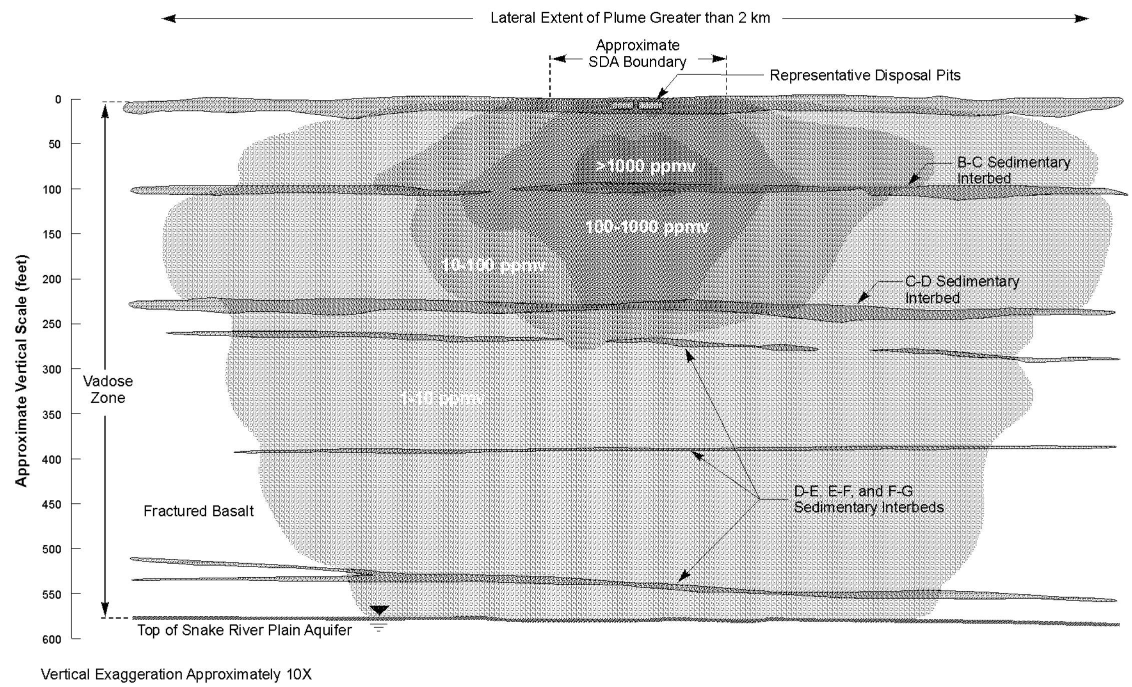


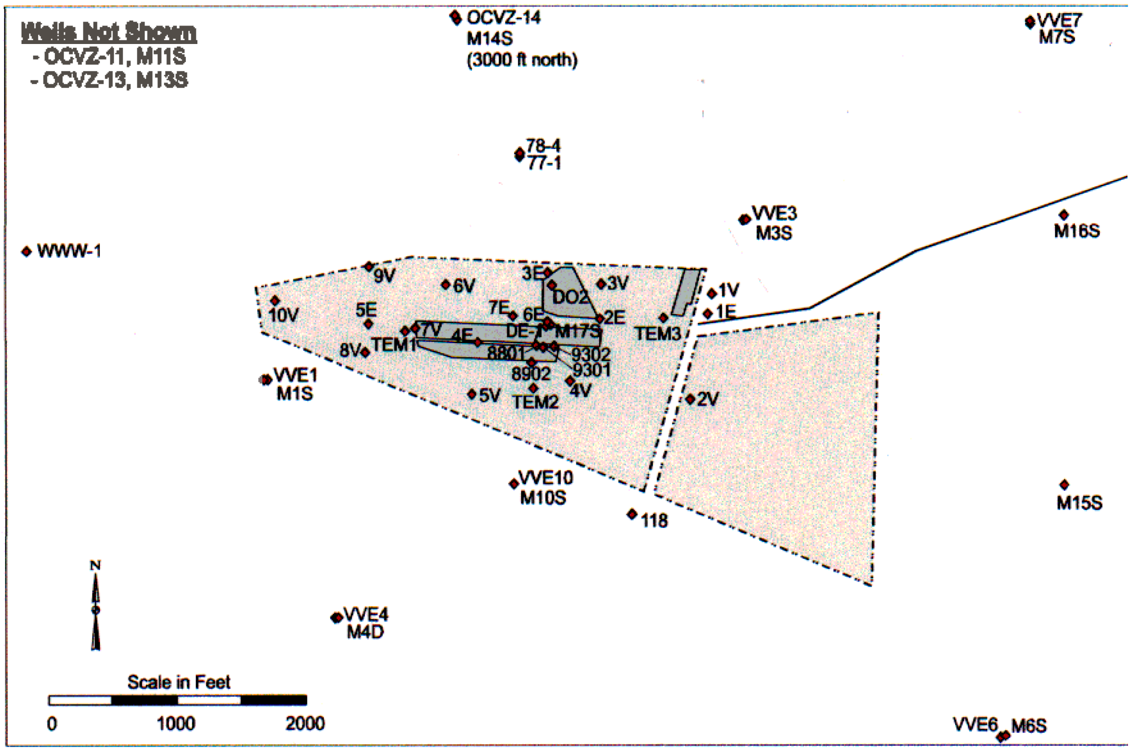
Figure 5-2. Conceptual drawing of the volatile organic compound plume before remedial operations.

Note: Concentrations are based on carbon tetrachloride soil-gas data.

5.2 Previous Evaluation Methods

Currently, the effectiveness of the VVET system is measured primarily by its ability to remove VOC mass from the vadose zone and reduce subsurface vapor concentrations. VOC mass removal is usually calculated and reported on a weekly basis for each VVET unit. Cumulative mass removed since the beginning of operations as well as mass removed during a specific operating period are presented in semiannual data reports. The most recent semiannual data report, *OU 7-08 End-Year Data Report, 2001* (McMurtrey, 2002a), provides documentation that during the period from July 1, 2001, to December 31, 2001, the VVET units removed and treated approximately 5,317 kg (11,722 lb) of total VOCs, including 3,320 kg (7,319 lb) of carbon tetrachloride; 837 kg (1,845 lb) of trichloroethene; 151 kg (333 lb) of tetrachloroethene; 232 kg (511 lb) of 1,1,1-trichloroethane; and 777 kg (1,713 lb) of chloroform. Since the start of Phase I in January of 1996, approximately 47,280 kg (104,234 lb) of total VOCs have been removed and treated, including approximately 30,326 kg (66,857 lb) of carbon tetrachloride; 6,722 kg (14,819 lb) of trichloroethene; 1,551 kg (3,419 lb) of tetrachloroethene; 1,870 kg (4,123 lb) of 1,1,1-trichloroethane; and 6,811 kg (15,016 lb) of chloroform as shown in Figure 2-3.

Volatile organic compound vapor concentrations at point locations in the subsurface are monitored on a regular basis to detect temporal trends resulting from operation of the VVET units. Figure 5-3 shows the locations and depths of the permanent vapor sampling ports located in and around the SDA. Vapor samples are collected and analyzed on a regular basis (usually monthly) from these vapor ports, and the data are presented in an annual vapor-port monitoring report (e.g., *Volatile Organic Compound Vapor Monitoring Results from Selected Wells at the Radioactive Waste Management Complex, Supplement 2001* [Housley 2002]). Figure 5-4 is an example of how carbon tetrachloride concentrations appear to have declined at Well 8801 in response to OCVZ operations. Well 8801 is approximately 23 m (75 ft) from Well 8901, a primary extraction well connected to VVET Unit A. The concentrations at the 24-m (78-ft) and the 40-m (131-ft) depth appear to have dropped in response to active extraction operations while concentrations at the 70-m (230-ft) depth appear less affected.



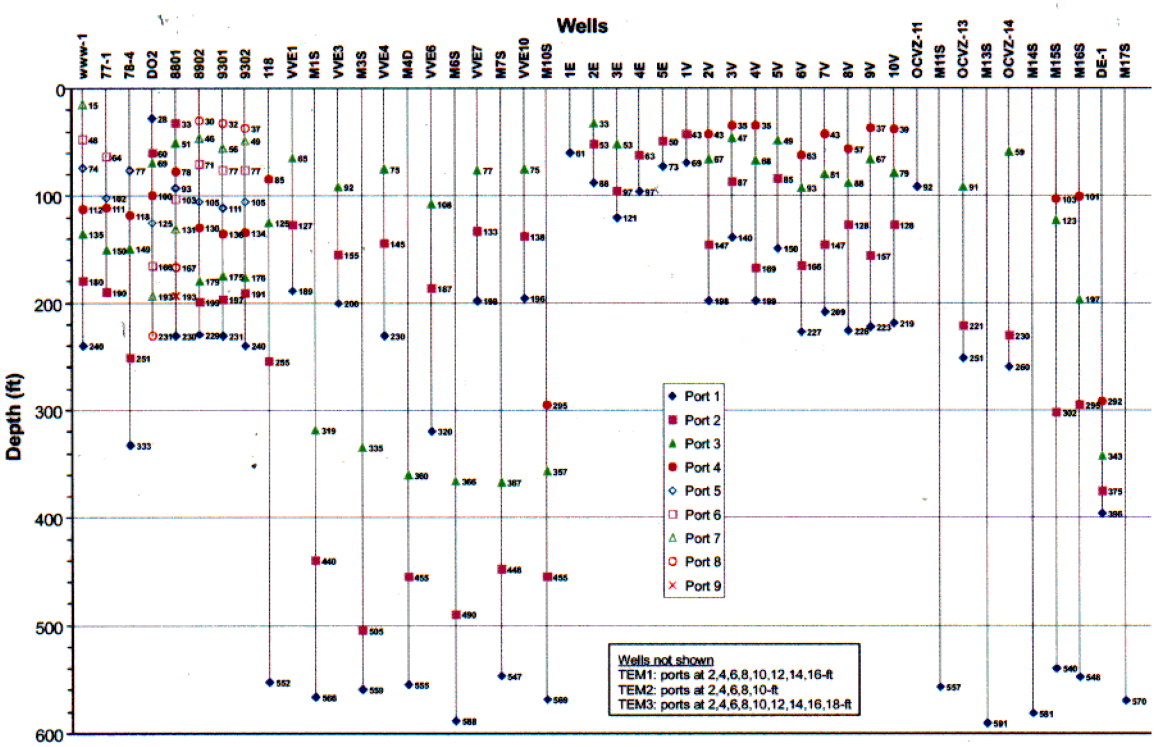


Figure 5-3. Location and depth of vapor sampling ports in and around the Subsurface Disposal Area.

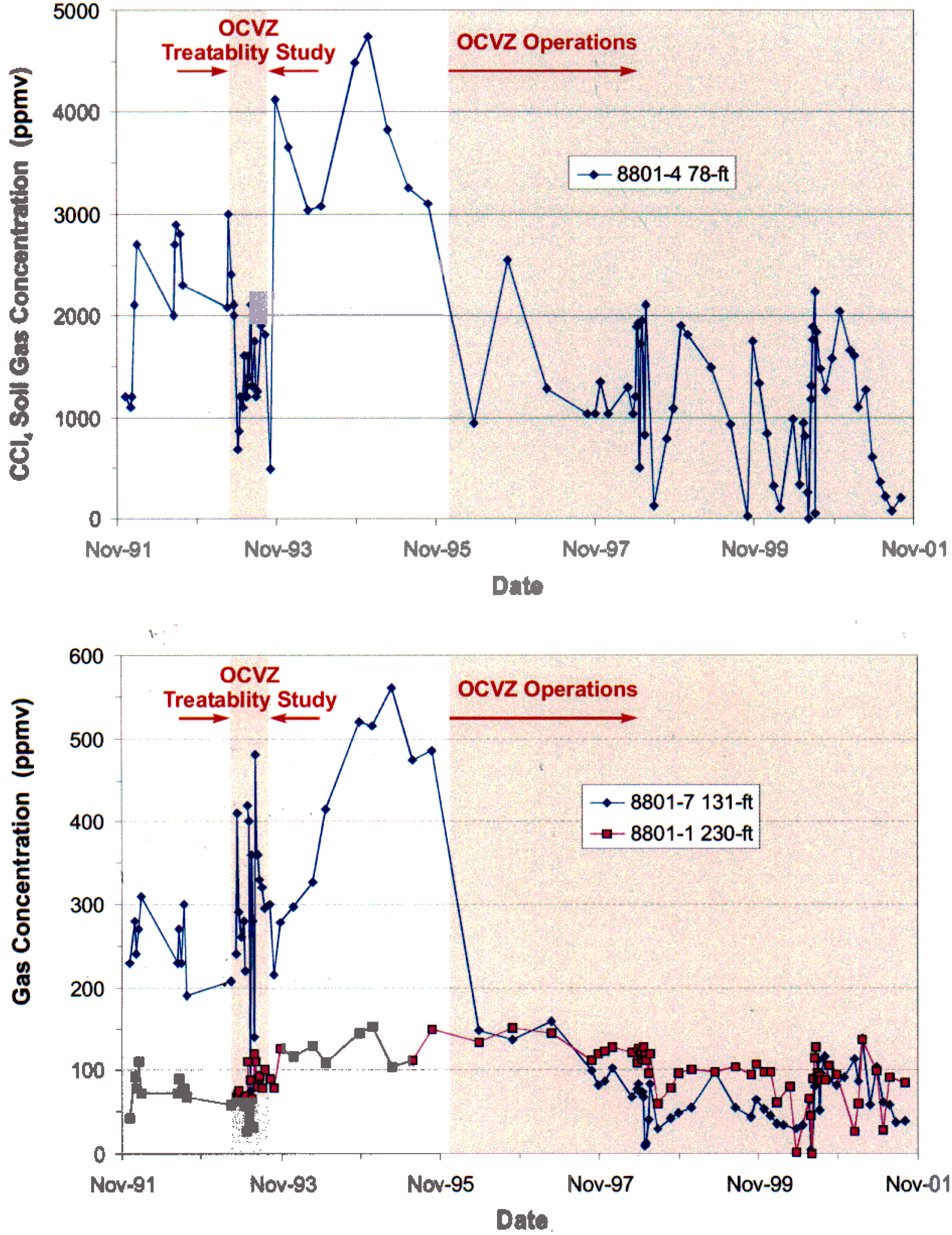


Figure 5-4. Carbon tetrachloride vapor concentration measured in vapor ports in Well 8801 at the Subsurface Disposal Area.

The final means of evaluating system performance has been to compare contour plots of subsurface concentration over time. Figure 5-5 compares the results of soil-gas concentrations at the 21-m (70-ft) depth just before OCVZ operations began (January 4, 1996) with those measured after more than 5 years of operations (April 3, 2001). The contour plots were created by interpolating (kriging) the data from all vapor ports in three dimensions and then viewing a horizontal slice at the 21-m (70-ft) depth. The figure shows concentrations in 2001 to be significantly less than they were 5 years ago, especially in the center of the SDA. However, the results may be misleading because the 2001 data may not reflect an equilibrium condition. In a classic soil-gas removal system, the subsurface concentrations are reduced and held to low levels when the system is operating. When the system is shut down, concentrations will typically rebound (increase) to an equilibrium condition dependent upon several hydrogeologic-, source-, and contaminant-specific factors. These data do not indicate whether or not the entire OCVZ system has been shut down long enough for concentrations to fully rebound. Nevertheless, the plots are informative and indicate that the OCVZ system has removed contaminant mass from the subsurface and that the extent of the plume has been reduced.

5.3 Current Evaluation

The evaluation methods discussed in Section 5.2 are a good indication that the VVET remedy is generally effective at removing mass. This current evaluation examines additional operational and monitoring data in more detail to gain a better understanding of the impact of operational activities on mass removal and to determine if the remedy can be made more effective.

Much of the data collected during routine operation of the OU 7-08 VVET system is presented in operational and monitoring data reports. This section describes recent efforts to combine, summarize, and analyze this data. This evaluation does not present any new data but rather presents existing data in a manner not previously considered. The combination and presentation of the different types of data (unit uptime/downtime, inlet VOC vapor concentration, and VOC vapor port concentration) enhance perspective and allow conclusions to be drawn that may not otherwise have been possible.

5.3.1 Operational History of Units A, B, C, and D

The first step taken in evaluating extraction efforts was to graphically display the operational uptime/downtime of the VVET units. This task was simplified by breaking the operational data into 1-day increments. A VVET unit was considered operational (uptime) for an entire day even if it was only on for part of the day. Though this slightly overestimates the total operating time, the error is small and certainly acceptable for the purposes of this exercise.

Table 5-1 contains a history of the shutdown periods for Units A, B, and C based on the assumption that operation for any part of a day constitutes full operation for that day. While Unit A has been shutdown more times than B or C, B and C have experienced major failures on more than one occasion. Major failures and their respective causes, which resulted in a shutdown of more than 3 months, are indicated by shaded text in Table 5-1. Table 5-2 contains a summary of the shutdown statistics for the VVET Units. Though Tables 5-1 and 5-2 cover operations through December 31, 2001, Unit D data are not shown in Tables 5-1 or 5-2 because the unit had not been through the shakedown period (McMurtrey 2001a) and only operated for a few weeks in 2001. Unit D, a replacement for Unit C, was tested twice before installation and began operation at the SDA for the first time on July 17, 2001.

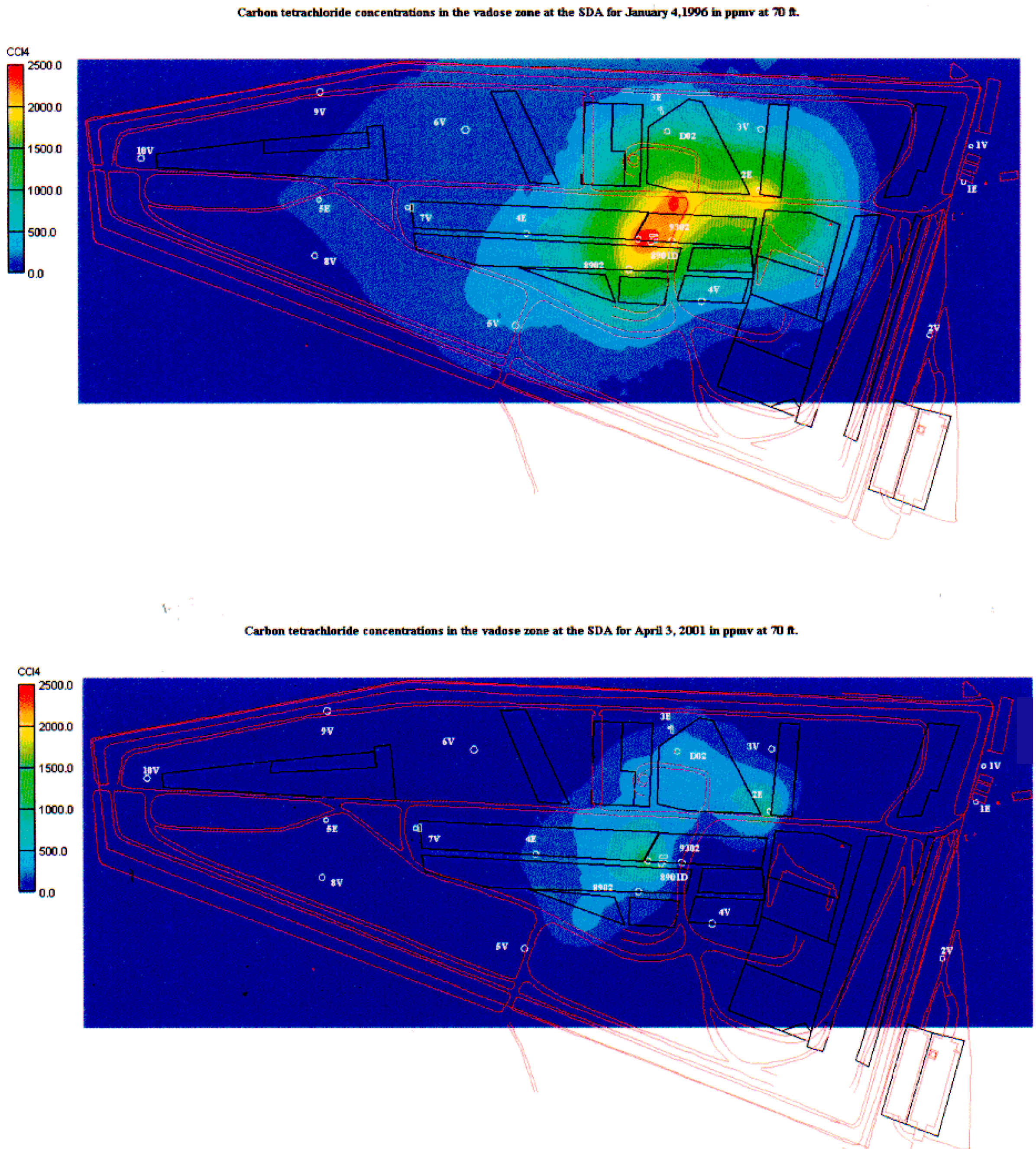


Figure 5-5. Comparison of carbon tetrachloride concentrations at the 21-m (70-ft) depth at the beginning of retrieval operations in 1996 and after 5 years of retrieval operations in 2001.

Table 5-1. Shutdown periods for Units A, B, and C (1996–2001).

	Unit A			Unit B			Unit C	
Shutdown	Restart	Days Off	Shutdown	Restart	Days Off	Shutdown	Restart	Days Off
1/13/96	1/15/96	2	1/28/96	1/30/96	2	1/28/96	2/7/96	10
1/28/96	2/6/96	9	2/4/96	2/5/96	1	2/23/96	3/4/96	10
2/23/96	3/1/96	7	2/23/96	3/4/96	10	3/19/96	4/1/96	13
3/3/96	3/4/96	1	3/6/96	3/8/96	2	4/6/96	4/9/96	3
3/19/96	4/1/96	13	3/17/96	4/3/96	17	5/15/96	5/28/96	13
4/6/96	4/8/96	2	4/6/96	4/16/96	10	5/31/96	6/5/96	5
5/13/96	5/30/96	17	4/27/96	4/29/96	2	7/5/96	7/8/96	3
6/9/96	6/10/96	1	5/15/96	6/5/96	21	7/12/96	7/22/96	10
7/5/96	7/8/96	3	7/3/96	7/8/96	5	7/27/96	1/5/97	162[a]
7/12/96	7/22/96	10	7/12/96	7/23/96	11	1/13/97	1/21/97	8
7/27/96	9/4/96	39	8/9/96	8/12/96	3	3/22/97	3/26/97	4
9/14/96	9/16/96	2	9/5/96	1/7/97	124[b]	4/4/97	5/5/97	31
10/2/96	1/6/97	96[a]	2/24/97	2/25/97	1	5/10/97	5/11/97	1
2/10/97	2/11/97	1	3/28/97	5/14/97	47	5/16/97	5/18/97	2
2/26/97	5/7/97	70	5/17/97	5/19/97	2	5/25/97	5/26/97	1
5/11/97	5/12/97	1	5/24/97	5/27/97	3	5/31/97	6/1/97	1
5/18/97	5/19/97	1	5/31/97	6/2/97	2	6/7/97	6/8/97	1
5/25/97	5/27/97	2	6/8/97	6/9/97	1	6/14/97	6/15/97	1
6/8/97	6/9/97	1	6/15/97	6/18/97	3	6/21/97	6/22/97	1
6/15/97	6/16/97	1	6/22/97	6/23/97	1	6/28/97	6/29/97	1
6/22/97	6/23/97	1	6/29/97	6/30/97	1	7/5/97	7/6/97	1
6/29/97	6/30/97	1	7/6/97	7/7/97	1	7/12/97	7/16/97	4
7/6/97	7/7/97	1	7/13/97	7/14/97	1	7/25/97	9/3/97	40
7/13/97	7/14/97	1	7/26/97	9/4/97	40	9/10/97	10/8/97	28
8/1/97	9/4/97	34	10/18/97	10/20/97	2	10/22/97	9/1/99	679[c]
11/22/97	11/24/97	2	12/30/97	1/6/98	7	9/3/99	9/6/99	3
5/2/98	6/30/98	59	1/11/98	1/15/98	4	9/16/99	9/18/99	2
7/10/98	7/20/98	10	5/2/98	6/30/98	59	10/14/99	10/17/99	3
9/21/98	9/24/98	3	7/4/98	7/20/98	16	10/28/99	10/31/99	3
11/27/98	12/7/98	10	11/27/98	12/9/98	12	11/4/99	11/8/99	4
1/14/99	2/15/99	32	1/14/99	8/13/99	211[c]	11/18/99	11/21/99	3
2/21/99	3/24/99	31	9/17/99	10/5/99	18	2/15/00	3/5/00	19
4/18/99	4/20/99	2	10/15/99	10/18/99	3	3/29/00	5/14/00	46
4/25/99	4/26/99	1	10/29/99	11/1/99	3	5/31/00	No restart	Indefinite
7/20/99	7/21/99	1	11/5/99	11/9/99	4			
9/17/99	9/19/99	2	11/19/99	11/24/99	5			
10/15/99	10/18/99	3	5/19/00	4/26/01	342[d]			
10/29/99	11/15/99	17	5/4/01	6/11/01	38			
12/27/99	1/3/00	7	7/9/01	7/16/01	7			
2/16/00	3/6/00	19	9/13/01	9/21/01	8			
6/21/00	8/24/00	64	10/1/01	10/2/01	1			
9/25/00	9/26/00	1	10/7/01	10/8/01	1			
11/13/00	11/15/00	2	10/27/01	10/29/01	2			
11/19/00	11/22/00	3						
11/25/00	11/28/00	3						
12/29/00	1/2/01	4						
1/19/01	3/15/01	55						
4/12/01	4/25/01	13						
6/1/01	6/4/01	3						
6/29/01	7/2/01	3						
7/20/01	7/22/01	2						
8/3/01	8/5/01	2						
9/7/01	10/16/01	39						
12/18/01	12/19/01	1						

Table 5-1. (continued).

Unit A			Unit B			Unit C		
Shutdown	Restart	Days Off	Shutdown	Restart	Days Off	Shutdown	Restart	Days Off

a. Transformer fire at Unit C; Unit A shutdown
b. Blower failure and replacement
c. Oxidizer failure and rebuild
d. Shell damage and rebuild

Note: shaded numbers indicate shutdown for major failure/rebuild.

Table 5-2. Summary of shutdown statistics for Units A, B, and C (1996–2001).

Statistic	Unit A		Unit B		Unit C	
Total number of whole days off	711	615	1,054	377	1,116	275
Number of times off more than 1 day	54	53	43	40	33	31
Average number of whole days off	13	12	25	9	34	9
Total days available	2,181	2,085	2,174	1,497	1,589[a]	748[a]
Percent time operated	67%	71%	52%	75%	30%	63%

a. Through May 31, 2000

Note: shaded numbers do not include shutdown for major repairs or failures indicated in Table 5-1.

The operational history for Units A, B, C, and D since the beginning of operations through December 31, 2001, as contained in Table 5-1 is displayed graphically in Figure 5-6. While the colored segments on the graph specify periods of uptime, the blank segments distinguish periods of downtime. The graph shows that Unit A has been the workhorse, operating more time than the other VVET units. Unit B has operated less than Unit A, and Unit C has operated even less than Units A or B. The original operation strategy for the VVET system was to operate the units for six weeks and then shut them down for two weeks to allow concentrations to rebound. After about one year, that pattern was adjusted to have the units operating on a nearly continuous basis and shut down only for preventive maintenance or an occasional rebound period. Much of the current downtime is the result of power outages, breakdowns, and other unplanned interruptions.

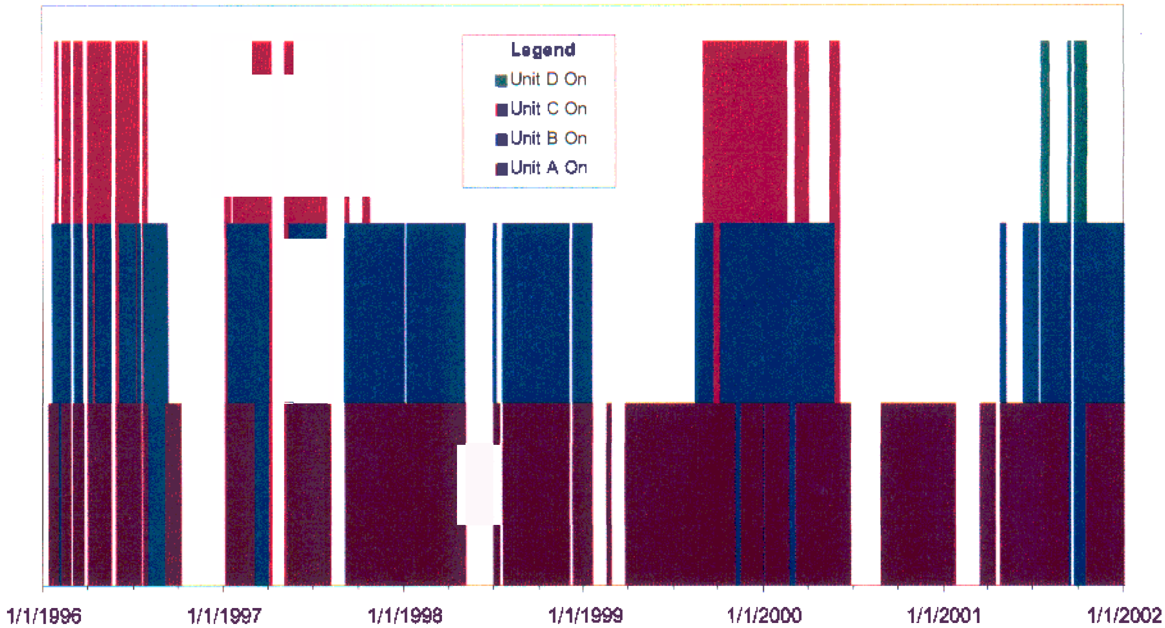


Figure 5-6. Operational history for Units A, B, C, and D since the beginning of operations, January 4, 1996–December 31, 2001.

5.3.2 Unit Inlet Samples of Volatile Organic Compound Concentrations

Inlet samples to the VVET units are taken once a day on scheduled workdays (Monday–Thursday). Figures 5-7, 5-8, and 5-9 show the inlet sample VOC concentrations on top of the operating history graphs for Units A, B, and C/D, respectively. A log scale is used because of the large range of concentrations between the five VOCs shown. But even on a log-scale plot, including this much data makes it cluttered and difficult to analyze. Therefore, the rest of this evaluation focuses only on carbon tetrachloride data. This is appropriate because carbon tetrachloride accounts for most of the VOC mass, and the VOC concentrations appear to occur in approximately the same ratios over the entire OCVZ operating history. This means that observations or conclusions made, based on carbon tetrachloride, could be extended to the other VOCs.

Figures 5-10, 5-11, and 5-12 show inlet carbon tetrachloride concentrations for Units A, B, and C/D, respectively. In these graphs, the concentrations are shown on a linear scale. A bar at the top of the graphs has been added to indicate the wells that were connected to the different units and the times they were connected.

When evaluating this data, some important questions to consider are as follows:

- Is the overall trend in the inlet concentration increasing, decreasing, or flat? If concentration trends are increasing, current operations may not be sufficient, and additional wells or increased flow rates may be necessary to improve removal. Some sort of source control may also be necessary if the source continues to release VOC mass to the subsurface. If concentration trends are decreasing, current operation strategies are almost certainly successful but possibly could use some modification to increase effectiveness. If concentration trends are flat, it is probable that the strategy may need some modification. The system may have reached a point of limiting returns where the system is removing relatively clean air (low VOC concentrations). In this case, it may be a good idea to shut the unit down for rebound or rotate to another well where extraction would be more effective (cycling).

- On a shorter time scale, do concentrations decrease when the unit is operating and increase when it is not? In other words, are the concentrations being drawn down when the units are on and are they rebounding when the units are off? If so, how high are the rebound concentrations? This is similar to Question 1 but is different because of the smaller time scale considered. Regardless, the remedy is usually the same, but the data can be used to help modify the strategy if necessary.

5.3.2.1 Discussion of Unit Inlet Concentration Data

5.3.2.1.1 ***Unit A***—In general, Unit A saw a slight decrease in inlet concentration from the beginning of operations until a scheduled 9-week rebound period beginning in June 2000 (see Figure 5-10). As might be expected, the most dramatic decreases in concentration occurred during the first several months of operation. Since that time, decreases have been modest or nonexistent. In general, the inlet concentration has increased after a shutdown period, but then concentrations decrease fairly rapidly after the unit is restarted. Most of the time, it appears that the inlet concentration goes down when Unit A is operating. The most notable exceptions occurred in the last half of years 2000 and 2001 when inlet concentrations went up significantly over a several month period despite sustained operations.

It is possible that the observed increase in inlet concentration to Unit A during the first half of years 2000 and 2001 was artificial. The observed concentration trend could be an artifact of the sampling procedure or the result of faulty analytical equipment. However, VOC concentrations in air measured with an open path Fourier transform infrared spectrometry instrument show similar increases during the last half of years 2000 and 2001 (McMurtrey, 2002b). Barring failure of the analytical equipment or sampling procedure, there are other possible explanations involving VVET operations, environmental conditions, or vadose zone source area disturbances. Three possible explanations are described below:

1. Unit B was not operating at the time, and the mass normally removed by Unit B was pulled toward Unit A and caused concentrations at Unit A to increase. However, because inlet concentrations to Unit A decreased during the time Unit B was down for about 7 months in 1999, it is unlikely that the shutdown of Unit B was the sole cause of the observed inlet concentration increase at Unit A.

2. Some seasonal effects such as temperature and moisture (or lack of moisture) combined to increase concentrations. This is plausible because there seems to be a seasonal trend in the data that is most pronounced in year 2000–2001. This is discussed in more detail in Section 5.3.3.

3. Installation of probes into VOC source areas could have released additional VOC mass into the subsurface, causing subsurface concentrations and inlet concentrations to rise. This is reasonable because the first probes were installed in December 1999 and then again in late summer of 2000 about the time the inlet concentration increased considerably despite the fact that Unit A was operating. The possible effects of probing are discussed in more detail in Section 5.3.4.

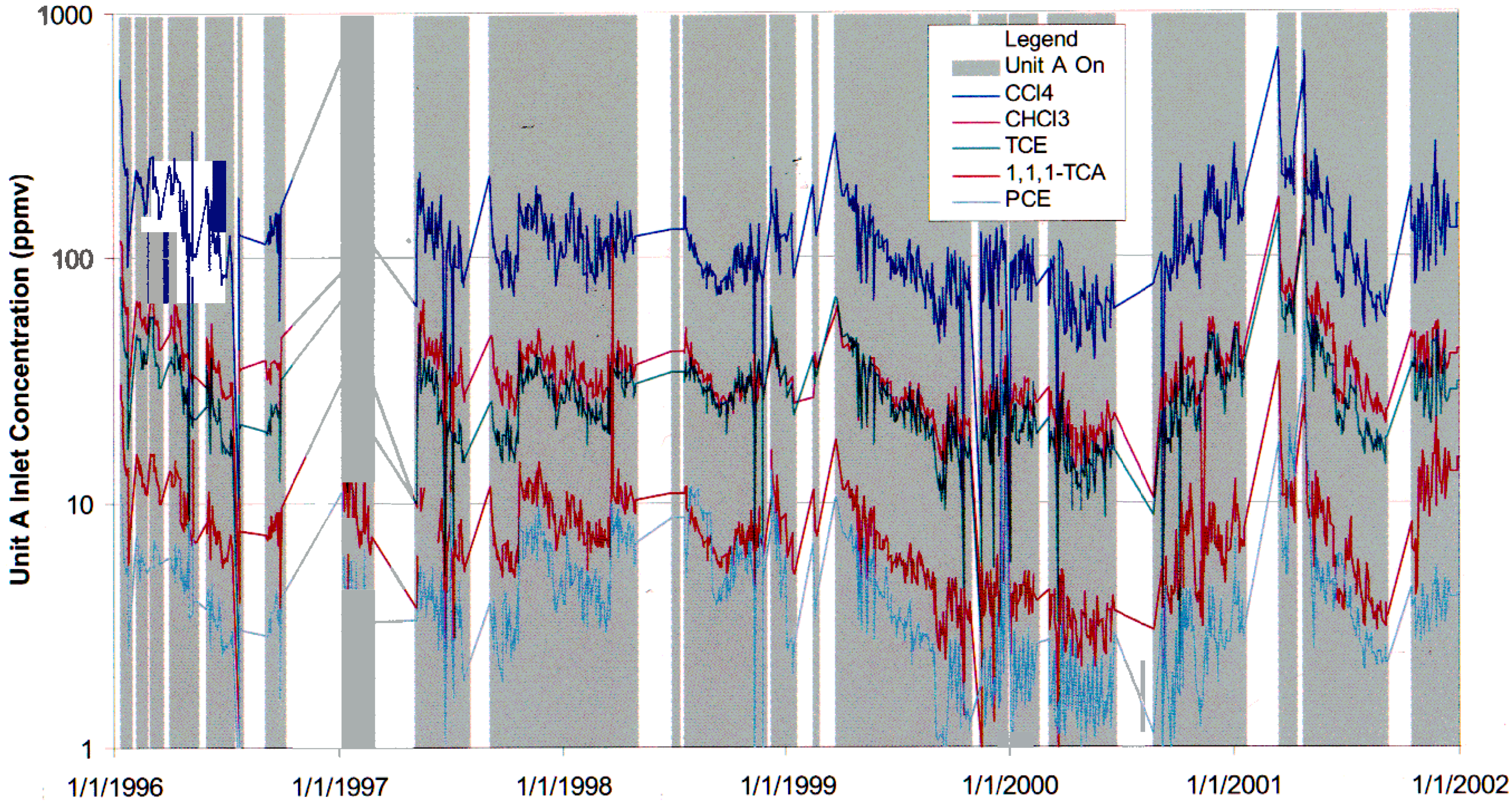


Figure 5-7. Unit A operating history and inlet volatile organic compound concentrations (log scale).

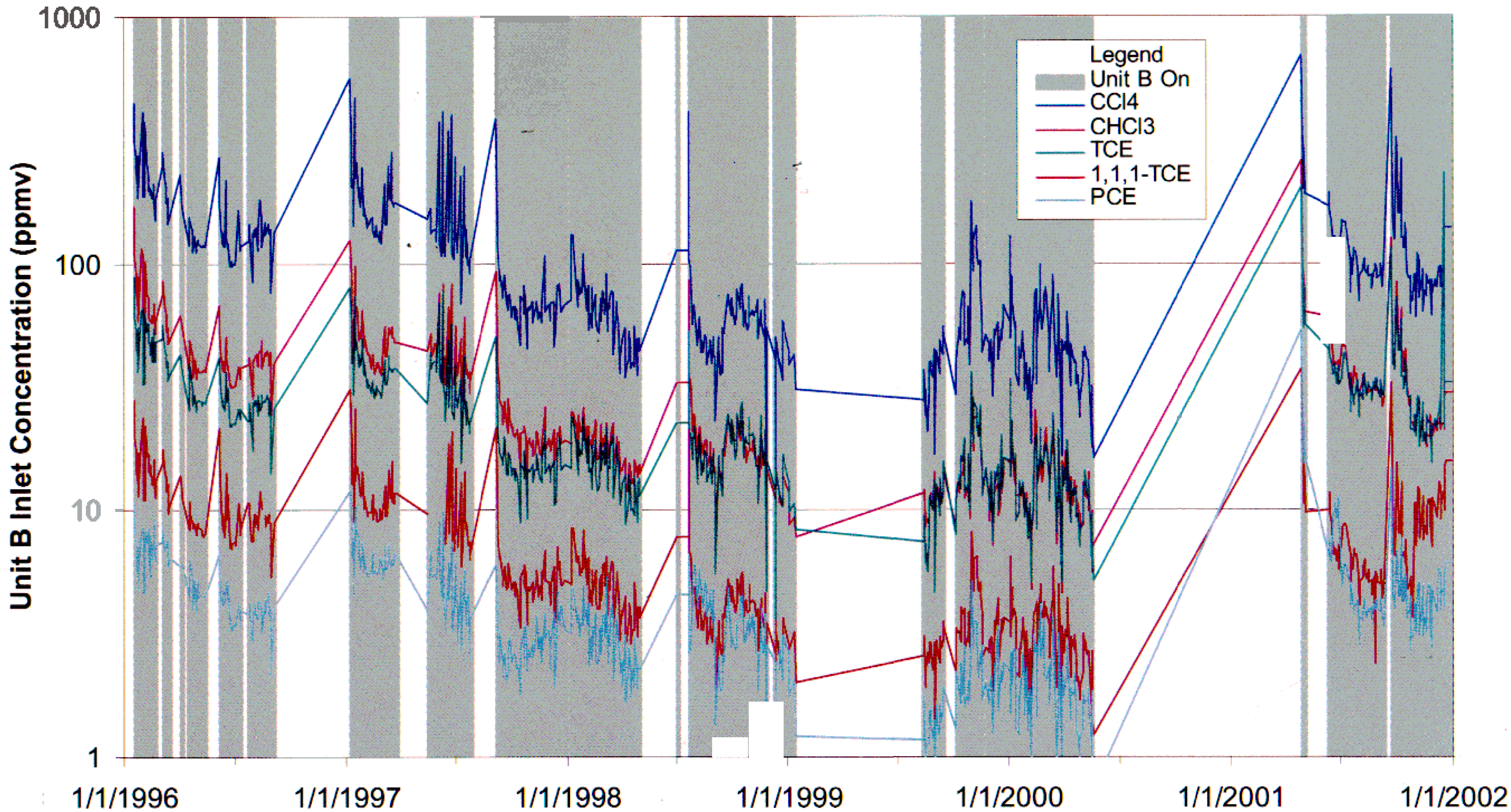


Figure 5-8. Unit B operating history and inlet volatile organic compoun con trations (log scale).

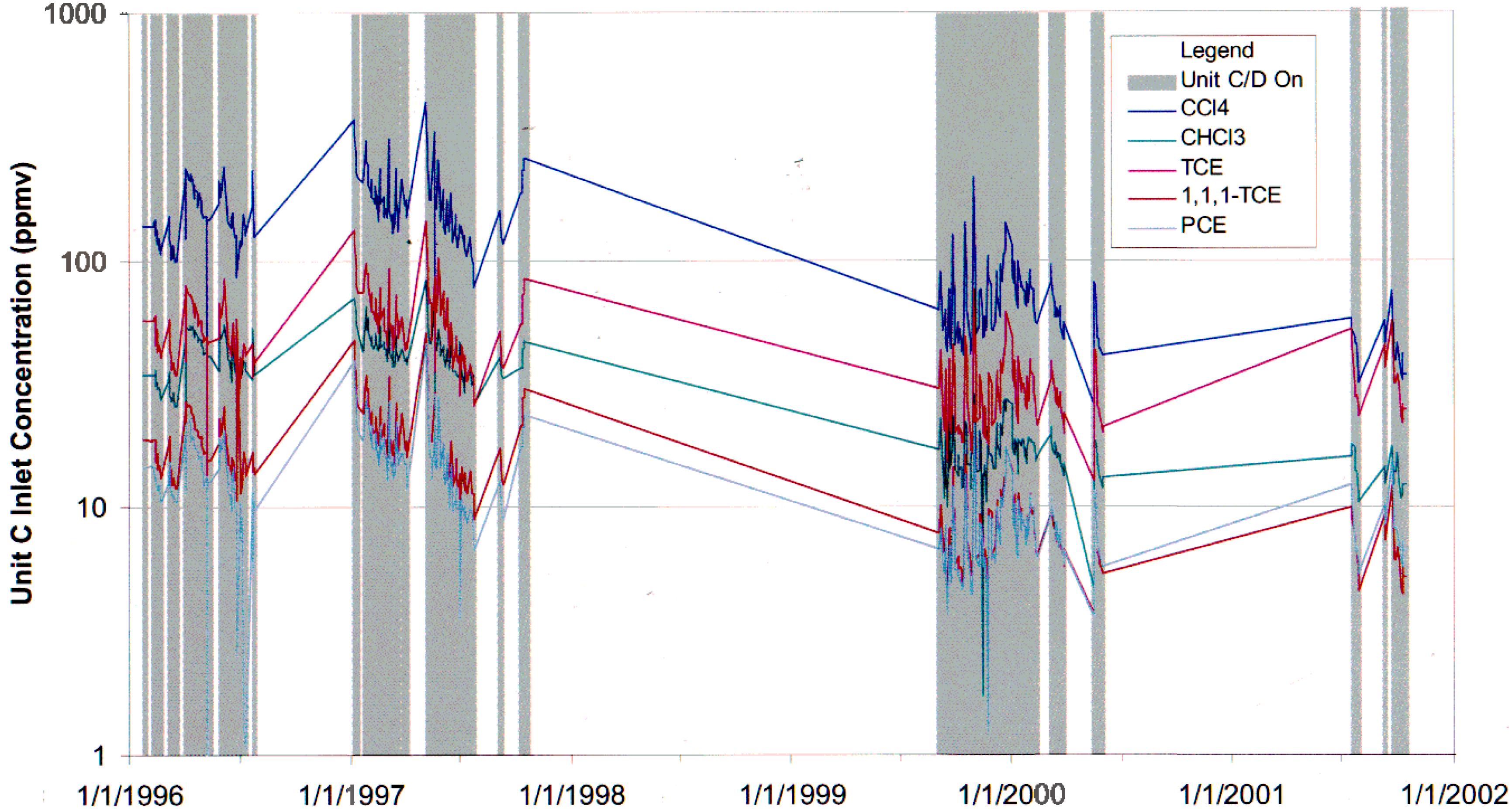


Figure 5-9. Unit C operating history and inlet volatile organic compound concentrations (log scale).

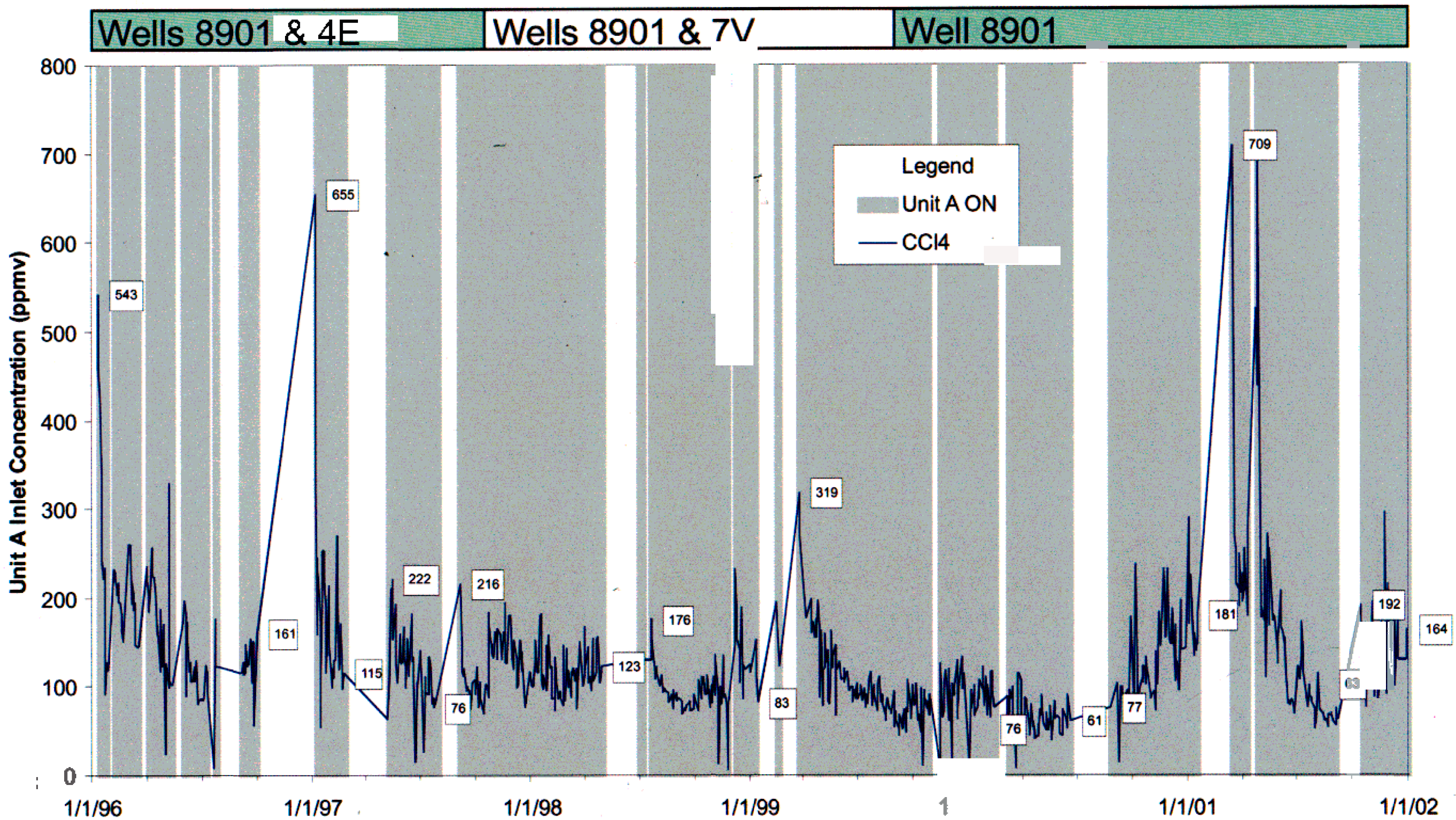


Figure 5-10. Unit A operating history and inlet carbon tetrachloride concentration (linear scale).

Note: The bar at the top of the graph indicates the wells that were attached to the unit during that time period.

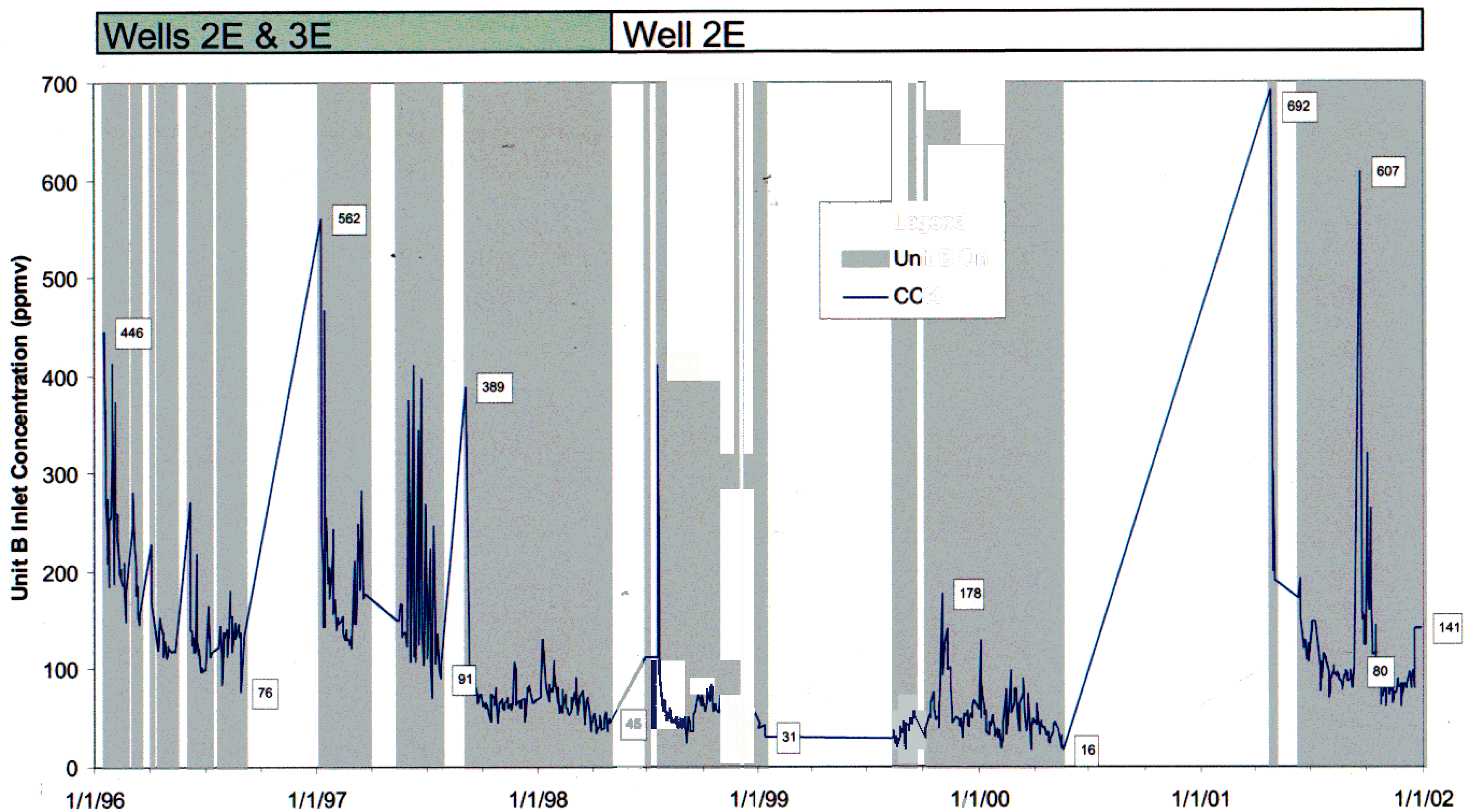


Figure 5-11. Unit B operating history and inlet carbon tetrachloride concentration (linear scale).

Note: The bar at the top of the graph indicates the wells that were attached to the unit during that time period.

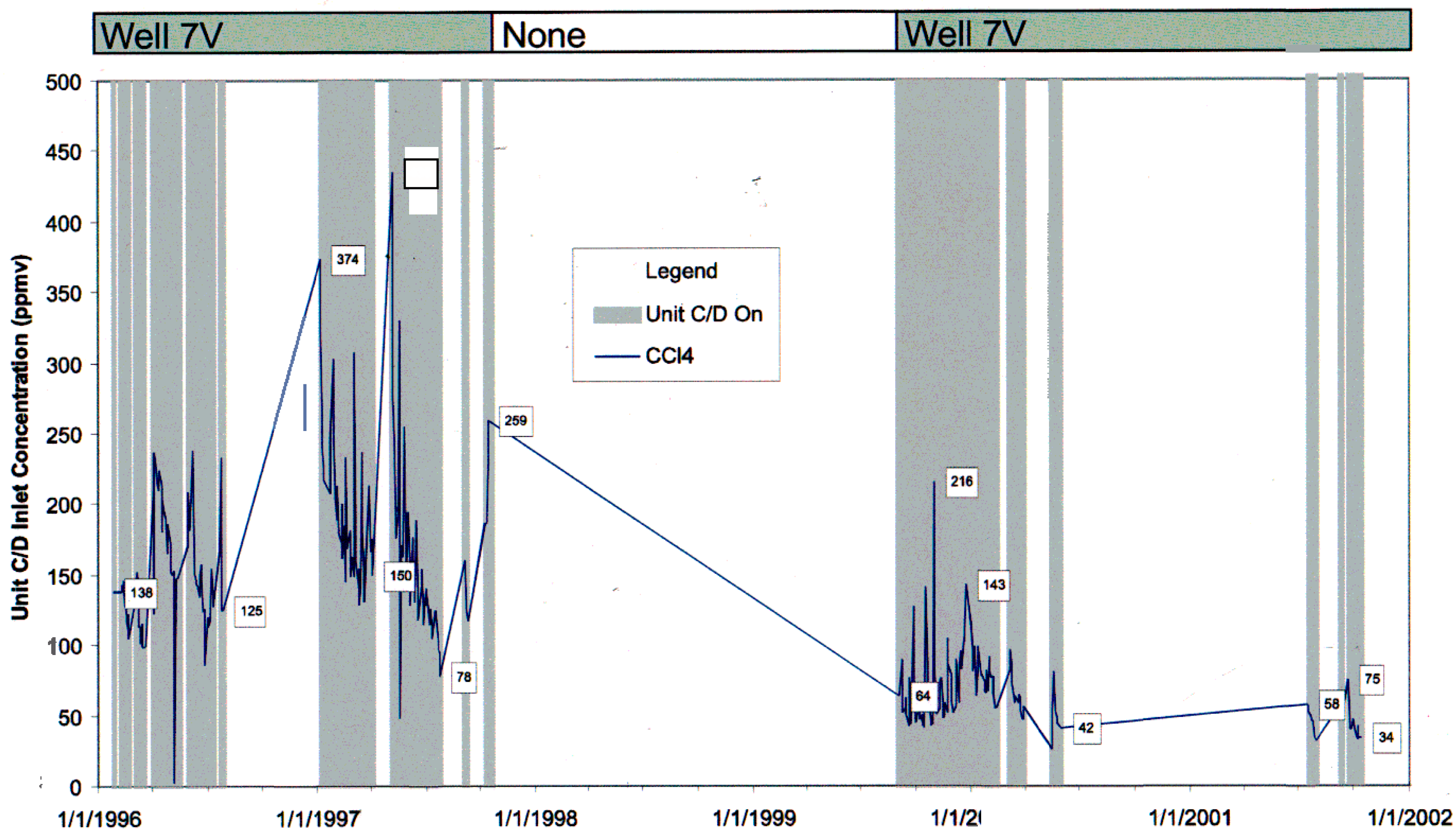


Figure 5-12. Unit C and D operating history and inlet carbon tetrachloride concentration (linear scale).

Note: The bar at the top of the graph indicates the wells that were attached to the unit during that time period.

5.3.2.1.2 Unit B—Figure 5-11 shows that the inlet concentration at Unit B decreased during the first 3 years of operation (1996–1998). However, from about July 1997 to May 2000, the inlet concentration has been relatively flat. There was essentially no decrease or increase in concentrations despite long periods of operation and shutdown. However, in April 2001, after nearly a yearlong shutdown, the inlet concentration after restart was the highest ever measured since operations began. Based on this, it appears that shutdown alone then is not responsible for the increase in concentration. Recall that the concentrations to Unit A increased during this time even though Unit A was running.

5.3.2.1.3 Units C and D— Inlet concentrations at Unit C were relatively flat during the first 2 years of operations. During that time, however, concentrations increased during periods of shutdown and decreased when the unit was operating. Then Unit C failed catastrophically and was shutdown for nearly 2 years while it was being rebuilt. During that period in 1998 and 1999, Well 7V was rerouted from Unit C into Unit A. Unit A appears to have had a significant impact on concentrations at Well 7V during that time because, after Unit C was rebuilt and Well 7V was piped back into Unit C, the inlet concentrations were noticeably less than they were before the long shutdown period. Since that time, the inlet concentration to Unit C has been flat despite another long shutdown period to replace Unit C with Unit D.

5.3.2.1.4 Summary of Inlet Data Concentration—In general, the concentrations to the VVET units have decreased slightly since the beginning of operations. In Units A and B, the largest declines occurred during the first few months after operations began but have been relatively flat for several years despite temporary increases. Unit C on the other hand saw very little, if any, overall decrease in concentrations during the first 2 years of operation. Concentrations to Unit C decreased only after Well 7V was piped into Unit A for a nearly a 2-year period while Unit C was being rebuilt. Currently, the inlet concentrations to Unit A are about the same or slightly less than they were shortly after operations began. Current inlet concentrations at Unit B are about 1/2–1/3 of what they were initially, and Unit D concentrations are approximately 1/2–1/4 of what they were when Unit C operations began.

5.3.3 Potential Effect of Atmospheric Temperature and Pressure

Volatile organic compound vapor concentrations can be affected by changes in both temperature and pressure. This section examines the data for correlation between atmospheric temperature or pressure and the inlet VOC vapor concentrations to the VVET units. The mean daily average temperature and pressure at Central Facilities Area were used because data for the RWMC was incomplete over the period examined. The National Oceanic and Atmospheric Administration office in Idaho Falls, Idaho, provided the temperature and pressure data.

5.3.3.1 Temperature. Figure 5-13 shows the inlet concentration to Unit A plotted against the average daily air temperature. The temperature data has been time-averaged using a 9-day moving window and scaled to make the graph less cluttered without compromising the analysis. Scaling is appropriate since it is the relative values and trends that are of concern. Also added to the figure is a trend line to indicate a trend (perhaps seasonal) in inlet concentration. The drawn-in trend line is not the result of a quantitative best-fit analysis; rather, it was drawn by hand after a visual inspection of the data. A possible seasonal trend in the data could be caused by changes in temperature or a change in subsurface moisture content as noted in Section 5.3.2.1.1.

While it appears that there is a relatively high degree of correlation between the inlet concentration data and temperature, the mechanism of how temperature changes affect sample concentration and the degree to which it occurs has not been investigated. Temperature can affect the rate of VOC release from the source, the rate of subsurface transport, the subsurface concentration, and the inlet sample concentration. Other seasonal changes such as moisture content could also play a role and help explain seasonal trends in inlet data.

5.3.3.2 Pressure. Figure 5-14 shows the inlet concentration to Unit A plotted against the average daily barometric pressure. Like temperature, the pressure data has been scaled to fit on the graph, which again is appropriate because the relative values and trends are important. Also shown is the same data set after scaling and time-averaging using a 9-day moving window. Pressure, unlike temperature, exhibits less of a seasonal effect. Pressure is most affected by diurnal temperature changes and weather patterns. The frequency of these changes is much too high to be analyzed on a 5-year time period as shown in Figure 5-14. Further analysis on a smaller time scale may be worthwhile but was not part of this investigation.

5.3.4 Possible Effects of Probe Installation on Source Release

In Section 5.3.2.1.1, some rather dramatic increases in the inlet concentration to Unit A were discussed. These increases began in the last half of years 2000 and 2001 when inlet concentrations went up significantly over a several-month period despite the fact that Unit A was operating. One of the possible explanations is that probes installed in VOC source areas disturbed remaining VOC waste and increased releases from the source area. Any release of additional VOC contamination into the subsurface could result in higher subsurface concentrations and consequently higher inlet VOC concentrations to the VVET units.

In order for probing to release more VOCs, there would have to be a VOC source remaining in the SDA pits. Shallow soil-gas survey results (Housley, Sondrup, and Varvel 2002) and chlorine logging of Type A probeholes[b] are evidence that VOCs still exist in the pits. This is not surprising given that the current estimated carbon tetrachloride inventory (8.2e+05 kg) is several times larger than originally estimated (Miller and Varvel 2001). For probing to cause a release, the VOCs do not necessarily have to still be containerized. The nature of the sludge is such that even if the containers have failed, there could exist masses of VOC-laden sludge that could be disturbed by probing and release VOCs.

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b. Miller, Eric C., A. Jeffrey Sondrup, and Nicholas E. Josten, 2002, *Preliminary Estimate of Carbon Tetrachloride and Total Volatile Organic Compound Mass Remaining in SDA Pits (Draft)*, INEEL/EXT-02-00140, Rev. A, Idaho National Engineering and Environmental Laboratory, Idaho Falls, Idaho.

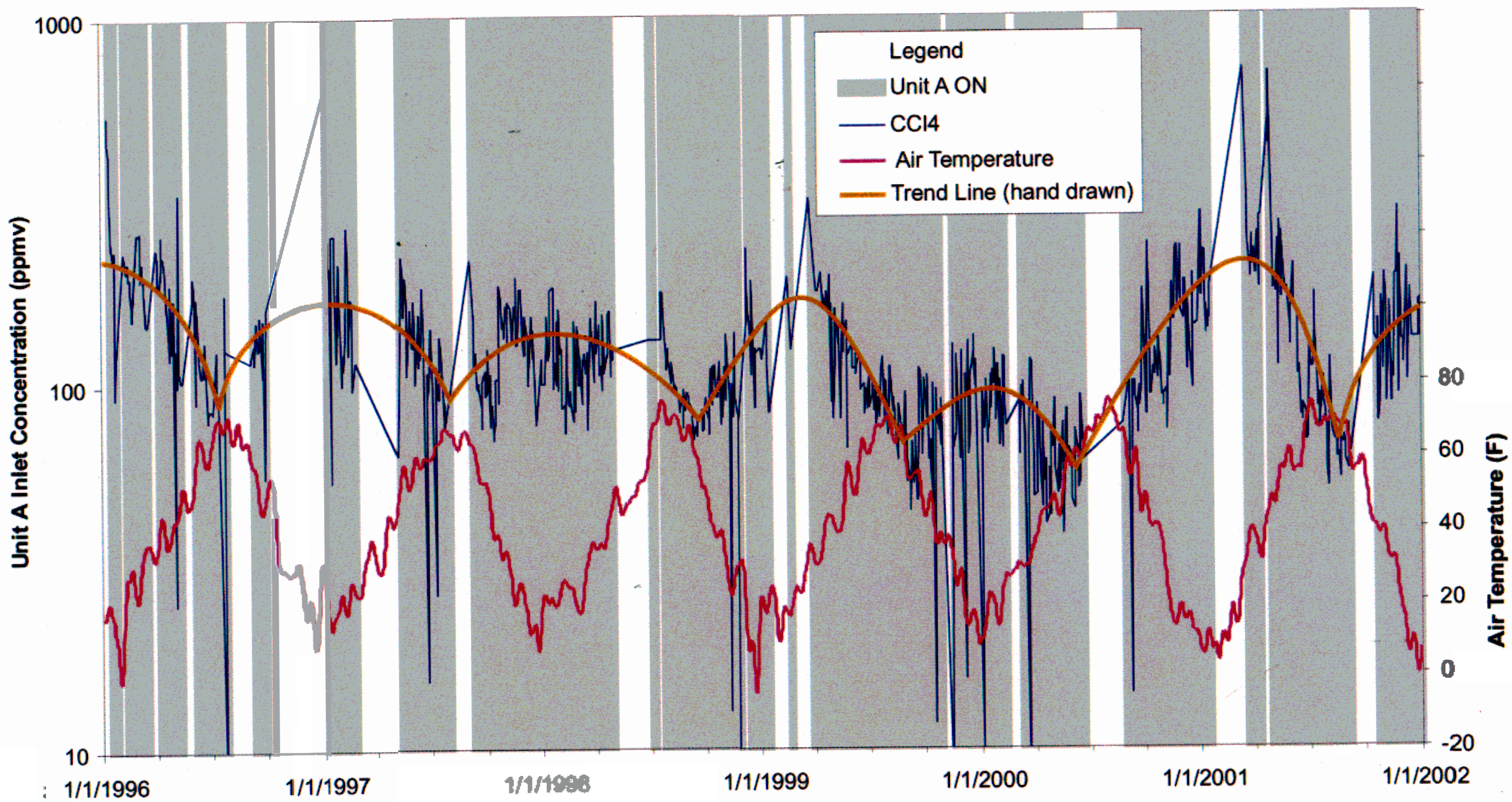

Figure 5-13. Unit A operating history and inlet carbon tetrachloride vapor concentration with mean daily air temperature.

Note: Temperature data is shown on a linear scale and was averaged using a 9-day moving window. The trend line was drawn in to call attention to the potential seasonal trend in the inlet concentration data.

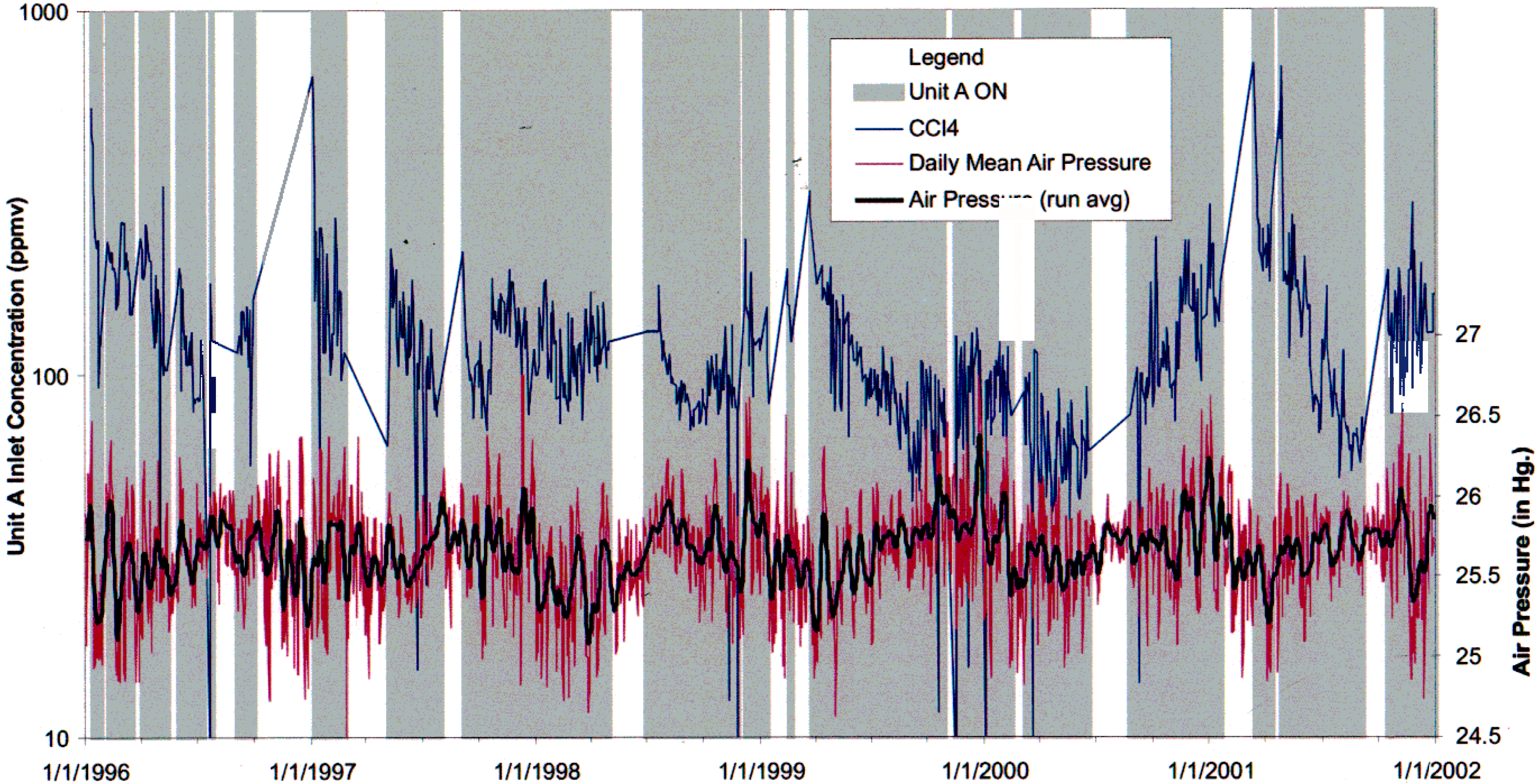

Figure 5-14. Unit A operating history and inlet carbon tetrachloride vapor concentration with mean daily air pressure.

Note: Pressure data is shown on a linear scale. The pressure data indicated with a thicker line was averaged using a 9-day moving window.